

## Annex D – LIFE CYCLE COSTING DEFINITIONS

**Affordability:** Can be considered as the degree to which the life cycle cost of an acquisition programme is *in consonance* with the long-range investment and force structure plans of national defence administrations. Affordability procedures establish the basis for fostering greater *programme stability* through the *assessment* of programme affordability and the *determination of affordability constraints*. In this context:

- *In consonance* means delivering systems that meet the customer's needs and budget.
- *Programme stability* means working towards sustainable opportunities.
- *Assessment* means creating a programme management strategy that guarantees programme viability.
- *Determination of affordability constraints* means bringing affordability to the foreground to avoid misconceptions in management and engineering which may ultimately lead to unaffordable design solutions.

**Analogy:** A technique used to estimate a cost based on historical data for an analogous system or subsystem. In this method, a currently fielded system, similar in design and operation to the proposed system, is used as a basis for the analogy. The cost of the proposed system is then estimated by adjusting the historical cost of the current system to account for differences (between the proposed and current systems). Such adjustments can be made through the use of factors (sometimes called scaling parameters) that represent differences in size, performance, technology, and/or complexity. Adjustment factors based on quantitative data are usually preferable to adjustment factors based on judgments from subject-matter experts.

**Analysis of Alternatives (AoA):** An analytical comparison of the operational effectiveness, suitability, and life-cycle cost of alternatives that satisfy established capability needs. Initially, the AoA process typically explores numerous conceptual solutions with the goal of identifying the most promising options, thereby guiding the concept refinement phase. Subsequently, the AoA is used to justify the rationale for formal initiation of the acquisition program. An AoA normally is not required for production decisions unless significant changes to threats, costs, or technology have occurred.

**Cost Analysis Requirements Description:** The CARD is used to formally describe Acquisition Category I and IA programs and systems in the United States DoD for purposes of preparing both the program office cost estimate (and the Component cost position, if applicable) and the OSD CAIG independent cost estimate. The CARD is provided in support of major milestone decision points (Milestone B, Milestone C, or the full-rate production decision review). In addition, for major AIS programs, the CARD is prepared whenever an economic analysis is required. The CARD is prepared by the program office and approved by the DoD Component Program Executive Officer (PEO). For joint programs, the CARD includes the common programme agreed to by all participating DoD Components as well as all unique program requirements of the participating DoD Components. DoD 5000.4-M, *DoD Cost Analysis Guidance and Procedures*, Chapter 1, provides further guidelines for the preparation of the CARD.

Note that the CARD, ideally, provides both narratives and tabular data in sufficient detail for the programme to be costed. Naturally, the exact level of detail provided in the CARD will depend on the maturity of the programme. Programmes at Milestone B are less well-defined than programmes at Milestone C or at full-rate production. In cases where there are gaps or uncertainties in the various programme descriptions, these uncertainties are, again ideally, acknowledged as such in the CARD. Dealing with program uncertainty in the CARD greatly facilitates subsequent sensitivity or quantitative risk analyses in the life-cycle cost estimate.

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**Contractor Cost Data Reporting System:** The primary means within the U.S. Department of Defense to systematically collect data on the development and production costs incurred by contractors in performing DoD acquisition program contracts. CCDR reports can provide for each contract a display of incurred costs to date and estimated incurred costs at completion by elements of the work breakdown structure, with nonrecurring costs and recurring costs separately identified. In addition, CCDR reports can display incurred costs to date and estimated incurred costs at completion by functional category (manufacturing, engineering, etc.). Each functional category is broken out by direct labour hours and major cost element (direct labour, direct material, and overhead). The CCDR manual (which provides report formats and definitions, specific report examples, and other related information) can be found at the Defense Cost and Resource Center (DCARC) web site. The DCARC is the OSD office responsible for administering the CCDR system.

**Cost Element Structure (CES):** A unit of costs to perform a task or to acquire an item. The cost estimated may be a single value or a range of values.

**Cost Estimating Relationships (CERs):** Equations that relate the cost of a weapon system or subsystem (or some other dependent variable) to one or more technical, physical, or performance characteristics of that system. CERs can range from simple rules of thumb derived as the average of a couple of data points to multi-variate regressions complete with a host of related statistics.

**Cost Estimating** (defined by SCEA, found in FAA Life Cycle Cost Estimating Handbook Sub-section 2.2): The art of approximating the probable cost or value of something based on information available at the time.

**Cost model** (taken from SAS-054 POW): A cost model is a set of mathematical and/or statistical relationships arranged in a systematic sequence to formulate a cost methodology in which outputs, namely cost estimates, are derived from inputs. These inputs comprise a series of equations, ground rules, assumptions, relationships, constants, and variables, which describe and define the situation or condition being studied. Cost models can vary from a simple one- formula model to an extremely complex model that involves hundreds or even thousands of calculations. A cost model is therefore an abstraction of reality, which can be the whole or part of a life cycle cost.

**Data** (taken from Joint publication 1-02 DoD Dictionary of Military and Associated Terms, 12/04/01, amend. 05/06/03 <http://centre.chots.mod.uk/jel/pdfdocs/jel/diction/termdict.pdf>): Representation of facts, concepts, or instructions in a formalised manner suitable for communication, interpretation, or processing by humans or by automatic means. Any representations such as characters or analog quantities to which meaning is, or might, be assigned.

**Earned Value Management (EVM):** A project management technique that objectively tracks physical accomplishment of work. EVM has the unique ability to combine measurements of technical performance (i.e. accomplishment of planned work), schedule performance (i.e. behind/ahead of schedule), and cost performance (i.e. under/over budget) within a single integrated methodology. EVM provides an early warning of performance problems while there is time for corrective action. In addition, EVM improves the definition of project scope, prevents scope creep, communicates objective progress to stakeholders, and keeps the project team focused on achieving progress.

EVM emerged as a financial analysis specialty in United States Government programmes in the 1960s, but it has since become a significant branch of project management. Implementations of EVM can be scaled to fit projects of all sizes and complexity.

**Economic Analysis:** A systematic approach to the problem of choosing the best method of allocating scarce resources to achieve a given objective. A sound economic analysis recognises that there are alternative ways

to meet a given objective and that each alternative requires certain resources and produces certain results. To achieve a systematic evaluation, the economic analysis process employs the following two principles:

Each feasible alternative for meeting an objective must be considered, and its life-cycle costs and benefits evaluated. All the costs and benefits are adjusted to “present value” by using discount factors to account for the time value of money. Both the size and timing of costs and benefits are important.

**Engineering Estimates:** With this technique, the system being costed is broken down into lower-level components (such as parts or assemblies), each of which is estimated separately for direct labour, direct material, and other costs. Engineering estimates for direct labour hours may be based on analyses of engineering drawings and contractor or industry-wide standards. Engineering estimates for direct material may be based on discrete raw material and purchase part requirements. The remaining elements of cost (such as quality control or various overhead charges) may be factored from the direct labour and material costs. The various discrete cost estimates are aggregated by simple algebraic equations (hence the common name “bottoms-up” estimate). The use of engineering estimates requires extensive knowledge of a system’s (and its components’) characteristics, and lots of detailed data.

**Estimation Methods:** Popular methods of estimating life cycle costs include analogy, engineering (bottoms-up), and parametric.

**Inflation:** A rise in the general level of prices, as measured against some baseline of purchasing power. In a U.S. DoD cost estimating environment, the following terms regarding inflation are commonly used:

**Base Year:** A point of reference that represents a fixed price level. In a weapon system acquisition context, this is often the fiscal year when a programme was initially funded.

### *Budget*

**Escalation:** Application of the effects of inflation to a dollar amount. De-escalation is the reverse, or removing the effects of inflation from a dollar value.

**Expenditures:** A charge against available funds or the actual payment of funds evidenced by voucher, claim, or other document approved by competent authority.

**Outlay Profiles:** Indicates the rate at which dollars in each appropriation are expected to be expended based on historical experience.

**Total Obligational Authority (TOA):** The yearly value the defense programme, roughly equal to new budget authority plus any prior year balance still available for obligation.

### *Dollars*

**Base-Year Dollars:** The money or prices expressed in terms of the purchasing power prevailing in a specified base year.

**Constant-Year Dollars:** Dollars expressed in their value at the time of any specified year, which may, but does not have to be, the base year. Also called “constant dollars.”

**Current-Year Dollars:** Money or prices expressed in terms of values actually observed in the economy at any given time. That is, 2010 Current Year dollars would be the actual amount of dollars you’d have to pay in 2010 to purchase something of a given value in that year.

**Then-Year Dollars:** Constant or base-year dollars deflated or inflated through the use of indices to show total money needed to buy those goods and services at the time expenditures are actually made. Or, put another way, Total Obligational Authority (TOA) that includes a slice of inflation to cover escalation of expenditures over a multi-year period.

**Indices**

**Raw:** An annual compounding of escalation or inflation rates from a fixed point of reference, designated 100 or 1.0, and called the base year.

**Weighted:** A combination of raw escalation or inflation indices and outlay rates that indicates the amount of escalation occurring over the entire period of time that is required to expend TOA.

**Learning and Experience Curves:** The **learning curve effect** and the closely related **experience curve effect** express the relationship between experience and efficiency. As individuals and/or organizations get more experienced at a task, they usually become more efficient at them. Both concepts originate in the adage, “practice makes perfect,” and both concepts are opposite to the popular misnomer that a “steep” learning curve means that something is hard to learn. In fact, a “steep” learning curve implies that something gets easier quickly.

The learning curve effect states that the more times a task has been performed, the less time will be required on each subsequent iteration. It was discovered by the 19th-century German psychologist Hermann Ebbinghaus. This relationship was probably first quantified in 1936 at Wright-Patterson Air Force Base in the United States, where it was determined that every time total aircraft production doubled, the required labour time decreased by 10 to 15 percent.

The experience curve effect is broader in scope than the learning curve effect encompassing far more than just labour time. It states that the more often a task is performed the lower will be the cost of doing it. The task can be the production of any good or service. Each time cumulative volume doubles, value added costs (including administration, marketing, distribution, and manufacturing) fall by a constant and predictable percentage.

**Life Cycle** (taken from Joint publication 1-02 DoD Dictionary of Military and Associated Terms, 12/04/01, amend. 05/06/03 <http://centre.chots.mod.uk/jel/pdfdocs/jel/diction/termdict.pdf>): The total phases through which an item passes from the time it is initially developed until the time it is either consumed in use or disposed of as being excess to all known materiel requirements.

**Life Cycle Cost (LCC)** (taken from RTO-TR-058 report): LCC consists of all direct costs plus indirect-variable costs associated with the procurement, O&S and disposal of the system. Indirect costs may include linked costs such as additional common support equipment, additional administrative personnel and non-linked costs such as new recruiters to recruit additional personnel. All indirect costs related to activities or resources that are not affected by the introduction of the system are not part of LCC.

Nature of Decision: LCC comprises the marginal costs (both direct and indirect) of introducing a new equipment or capability. LCC is used as a minimum for the analysis of alternatives, it does not include notional allocation of costs, whereas TOC and WLC might do so. LCC is used to compare options of alternatives, and often for economic analyses.

**Military Requirements:** (taken from Joint publication 1-02 DoD Dictionary of Military and Associated Terms, 12/04/01, amend. 05/06/03 <http://centre.chots.mod.uk/jel/pdfdocs/jel/diction/termdict.pdf>): An established need justifying the timely allocation of resources to achieve a capability to accomplish approved military objectives, missions, or tasks. Also called operational requirement.

**Operations:** (taken from JWP 0-01.1, Edition 6, <http://www.chots.mod.uk/jointwar/>): A military action or the carrying out of a strategic, tactical service, training, or administrative military mission: the process of carrying on combat, including movement, supply, attack, defence and manoeuvre needed to gain the objectives of any battle or campaign.

**Parametric Estimating:** This technique uses regression or other statistical methods to develop Cost Estimating Relationships (CERs). A CER is an equation used to estimate a given cost element using an

established relationship with one or more independent variables. The relationship may be mathematically simple (e.g. a ratio) or it may involve a complex equation (often derived from regression analysis of historical systems or subsystems). CERs should be current, applicable to the system or subsystem in question, and appropriate for the range of data being considered.

**Product** (taken from <http://www.ams.mod.uk>): The results of activities or processes. It includes (taken from RTO-TR-058 report) the products delivered to the user and the specific means required for developing and manufacturing these products. The products delivered to the user encompass the main system (aircraft, tank, etc.) and its support elements (spares, support equipment, facilities, documentation, etc.).

**Project** (taken from <http://www.ams.mod.uk>): The structure of authorities, resources and capabilities that supplies defined products and / or services within agreed time, cost and performance criteria.

**Risk** is exposure to loss. Or, in a weapon-system acquisition context, it is “a measure of the potential inability to achieve overall program objectives within defined cost, schedule, and technical constraints and has two components: (1) the **probability/likelihood** of failing to achieve a particular outcome, and (2) the **consequences/impacts** of failing to achieve that outcome”.

**Standardised Product**: (taken from JWP 0-01.1, Edition 6, <http://www.chots.mod.uk/jointwar/>): A product that conforms to specifications resulting from the same or equivalent technical requirement. NATO standardised products are identified by a NATO code number.

**Standardised Requirement** (taken from JWP 0-01.1, Edition 6, <http://www.chots.mod.uk/jointwar/>): Within NATO, a broad statement identifying the levels of standardisation that should be achieved within specific areas of operations, materiel, administration and the related procedures”.

**Sensitivity Analysis**: Attempts to demonstrate how the cost estimate would change if one or more assumptions change. Typically, for the high-cost elements, the analyst identifies the relevant cost-drivers, and then examines how costs vary with changes in the cost-driver values. For example, a sensitivity analysis might examine how maintenance manning varies with different assumptions about system reliability and maintainability values, or how system manufacturing labour and material costs vary with system weight growth. In good sensitivity analyses, the cost-drivers are not changed by arbitrary plus/minus percentages, but rather by a careful assessment of the underlying risks. Sensitivity analysis is useful for identifying critical estimating assumptions, but has limited utility in providing a comprehensive sense of overall uncertainty.

**System** (taken from <http://www.ams.mod.uk>): A human-made entity with a distinguishing and defined purpose that draws on integrated, constituent parts, each of which does not individually possess the required overall characteristics or purpose.

**Task** (taken from RTO-TR-058 report): Is the most elementary process or piece of work to be done, especially one done regularly to obtain an expected result and specified in terms of performance, cost and time. The performance of a task is entrusted to an identified actor and usually requires human, material and financial resources allocation.

**Total Ownership Cost (TOC)**: Total ownership cost consists of the elements of a programme’s life cycle cost, as well as other infrastructure or business processes costs not necessarily attributable to the programme. This may include items such as common support equipment, common facilities, personnel required for unit command, administration, supervision, operations planning and control, fuel and munitions handling.

Nature of Decision: TOC represents all costs associated with the ownership of a system except non-linked fixed costs that are related to the running of the organisation. TOC is used for budgeting

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purposes, determining the use of services between systems, for optimisation purposes and for financial analysis.

**Uncertainty:** Is the indefiniteness or variance of an event. It captures the phenomenon of observations, either favourable or unfavourable, falling to the left and right of a mean or median value.

**VAMOSOC:** The U.S.'s Visibility and Management of Operating and Support Costs (VAMOSOC) system is the set of data and data management systems for the collection, display and cataloguing of historical O&S costs, related data, and associated factors that determine those costs, by individual defence programme. Each military department in the U.S. DoD is responsible for developing their own VAMOSOC systems; hence, there is no single VAMOSOC system, but rather several closely related but independent VAMOSOC systems. VAMOSOC data can be displayed in several different formats, including the CAIG standard cost element structure. Data can be obtained for entire systems, or at lower levels of detail. VAMOSOC provides not only cost data, but related non-cost data (such as OPTEMPO or maintenance man-hours) as well. This type of data is useful for analogy estimates (between proposed systems and appropriate predecessor or reference systems) and for “bottoms-up” engineering estimates (for fielded systems or components, possibly adjusted for projected reliability and maintainability growth). VAMOSOC data should always be carefully examined before use in a cost estimate. The data should be displayed over a period of a few years (not just a single year), and stratified by different sources (such as major command or base). This should be done so that abnormal outliers in the data can be identified, investigated, and resolved as necessary.

**Whole Life Cost (WLC)** (taken from RTO-TR-058 report): WLC consists of all elements that are part of TOC plus indirect, fixed, non-linked costs. These latter may include items such as family housing, medical services, ceremonial units, basic training, headquarters and staff, academies, recruiters. In WLC all costs or expenses that are made by the organisation are attributed to the systems or products they produce.

Nature of Decision: As WLC represents the total budget provision including such element as headquarters costs, it allows the visibility of the complete allocation of funds. WLC is used for a strategic view and high level studies.

**Work Breakdown Structure (WBS):** A technique for representing all the components, software, services and data contained in the project scope statement. It establishes a hierarchical structure or product oriented “family tree” of elements. It is used to organise, define and graphically display all the work items or work packages to be done to accomplish the project’s objectives.